AN

INAUGURAL DISSERTATION

ON

RESPIRATION:

BEING

An APPLICATION *of the* PRINCIPLES *of the* NEW CHEMISTRY *to that* FUNCTION.

SUBMITTED TO THE PUBLIC EXAMINATION

OF THE

FACULTY OF PHYSIC,

UNDER THE AUTHORITY OF THE

TRUSTEES OF COLUMBIA COLLEGE

IN THE

STATE OF NEW-YORK:

FOR THE DEGREE OF

DOCTOR OF PHYSIC;

ON THE THIRTIETH DAY OF APRIL, 1793.

By JOSEPH YOULE,
Citizen of the State of New-York.

Hominem autem Jova Deus quum ex terræ pulvere formaviffet, et in ejus nares fpiritum vitalem infpiraviffet, ex quo effet animans homo effectus. GEN.

NEW-YORK:
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—1793.—

Imprimatur.

William Pitt Smith.

TO

JOSEPH YOUNG,

PHYSICIAN;

AND

WILLIAM PITT SMITH,

PROFESSOR OF MATERIA MEDICA
IN COLUMBIA COLLEGE:

INDEBTED to you for the foundation of the ſmall Medical Superſtructure, which, through PROVIDENCE, *I have been enabled to erect—having piloted my little Bark to the Haven of her Deſire; if any thing in the following pages ſhall be found worthy of attention,*

PERMIT *them to be* DEDICATED *to you,*

With every mark of ESTEEM *and* RESPECT,

By your FRIEND *and* PUPIL,

The AUTHOR.

TO

SAMUEL BARD, M. D.

PROFESSOR OF CLINICAL MEDICINE,

AND

DEAN OF THE MEDICAL FACULTY:

THIS

DISSERTATION

Is inſcribed,

As a mark of reſpect.

AN

APPLICATION *of the* PRINCIPLES

OF THE

NEW CHEMISTRY *to* RESPIRATION.

TO live and to breathe are ſynonymous expreſ-ſions. Reſpiration is, therefore, a function of the animal body, with propriety termed *vital.* It would be a pleaſing, as well as profitable undertaking, to trace the progreſs of the human mind in the inveſti-gation of this phænomenon of being. Notwith-ſtanding it has engaged the attention of Phyſicians and Philoſophers of every age, nothing has been written on the ſubject, till within a few years, which is worthy of attention. The rapid improvements in the ſcience of *Aerology*, of which Doctor PRIESTLY is the diſcoverer, have enabled the *moderns* to view the ſubject in a more juſt manner than the *ancients* could poſſibly have done.

Air is neceſſary to the exiſtence of all organized beings. We find none exiſting where they are not admitted to its contact; even plants, as well as ani-mals, are found by experiment to die *in vacuo.* Nature

Nature has taken great pains to provide animals, even of the moſt inſignificant kind, with organs for bringing their blood ſufficiently in contact with the fluid in which they live. This is inſtanced in a manner remarkably curious in inſects, in their different modes of exiſtence. From numerous obſervations it appears, that air is more eſſential to animal life than aliment. It forms a great part of the food of plants, and probably alſo of animals; but each of thoſe claſſes of being requires it of different kinds: that which is the moſt ſalubrious to plants being noxious to animals; and that which is emitted as excrementitious by the former, moſt ſalutary to the latter. Thus, by an unequalled deſign, are thoſe two kingdoms made to labour for each other, and the balance between the components of our atmoſphere preſerved.—The death of animals, by ſubmerſion, ſtrangulation, and ſuffocation, is produced by a privation of this all-vivifying fluid. We may be eaſily convinced of its eſſentiality to life, by voluntarily ſuſpending reſpiration a few moments.

The vaſt ærial ocean in which we continually move, although apparently a ſimple fluid, is in fact a very heterogeneous maſs. It is compoſed of the various ſubſtances which are capable of being volatilized at the temperature Preſure. at which it exiſts, and which it can by its ſolvent power ſuſpend. Monſ. Lavoisier has proved, ſynthetically and analytically, that it is compoſed of *oxigenous gas*, and *mephetic airs*, in the proportions of 27 and 73 to the 100 parts.

This

This *mephetis* confifts chiefly of *azotic*, although it contains a fmall portion of *carbonic* and *hydrogenous gafes.**

That *carbonic gas* enters as an ingredient in the compofition of our atmofphere, has been proved to a demonftration. It is fufficient for this purpofe to mention, that lime water expofed to the air is rendered turbid, the lime becoming precipitated; and that cauftic alkalies (pure alkalies) are *carbonated*, or rendered effervefcent.

That *hydrogenous gas* exifts in the atmofphere, has not fo generally been allowed: but whoever will confider what a vaft quantity of this gas is exhaled from marfhes, mines, putrifying animal and vegetable fubftances, will not have a doubt remaining on this head.

The airs, then, which compofe our atmofphere, are, the *oxigenous*, *azotic*, *carbonic*, and *hydrogenous*.†

Now,

* The oxigenous, azotic, carbonic, and hydrogenous gafes of the French Chemifts, are fynonymous with the dephlogifticated, phlogifticated, fixed, and inflammable airs of PRIESTLY.

† The mechanical properties of the atmofphere have, till very lately, entirely attracted the notice of Philofophers. The attention of men of the greateft eminence is now turned towards its compofition. The proportions of the ingredients in this fluid muft vary according to a variety of circumftances and fituations. The analyfis of the accurate LAVOISIER, already mentioned, is about the medium, and may be moft relied upon, as his abilities and apparatus enable him to do juftice to the inquiry. The proportion of carbonic gas is generally eftimated at an hundreth part, that of the hydrogenous is not afcertained. Probably neither are effential to the compofition of atmofpheric air, as the azotic gas is fufficient to qualify the action of the oxigenous.

Now, as animals cannot live without air, it muſt be ſome one of theſe components of the atmoſphere in particular, which ſupports their exiſtence, or the whole collectively.

Azotic gas (as its name ſignifies) is noxious to animal life. "It cannot be breathed by animals, neither will it admit of the combuſtion of inflammable bodies, nor of the calcination of metals." If common air be inſpired into the lungs, and again expired into a receiver, the volume becomes diminiſhed, while the *azotic gas* remains the ſame both in quantity and quality. It is, therefore, unfit for the purpoſes of reſpiration. Hereafter it will appear, that reſpiration is not merely a paſſive function; that it is not confined to the mere reception and emiſſion of air.

The unreſpirability of *carbonic gas* was long ſince ſhewn by VAN HELMONT, and has ſince been proved by HALES, PRIESTLY, and others. It is manifeſted by the experiments which have been made on dogs in the *grotto del cano*, and by accidents which happen in breweries, cellars, and places where the proceſs of fermentation is going on. It is this gas which produces the fatal effects that follow from the combuſtion of charcoal in confined places. The experiments which have been made on animals in the air exhaling from mineral waters, prove the ſame fact. It is further corroborated by the actual experiments of the Abbé NOLLET, and the intrepid PILATRE DE ROSIER,

Rosier, who breathed it at the hazard of life: De Rosier had not taken more than two or three inſpirations, before he was ſeized with all the ſymptoms of apoplexy. Bergman obſerves, that it kills animals inſtantaneouſly, and that the hearts of animals ſo deſtroyed are entirely deprived of their irritability.

Hydrogenous gas is likewiſe incapable of ſupporting reſpiration. "Birds, placed ſucceſſively in a veſſel filled with this air, died without producing the ſmalleſt perceptible change in it." M. Chaptal ſays, that he reſpired it himſelf, and found that the ſame air might be taken into the lungs ſeveral times without danger; and that it was not in the leaſt vitiated or diminiſhed after the experiment. De Rosier likewiſe inſpired it ſeveral times with impunity. From theſe facts it appears that *hydrogenous gas* is incapable of being decompounded in the lungs: It is then merely a paſſive ſubſtance in reſpiration, producing death by a negation of ſome other principle which can ſupport this proceſs.*

Having aſcertained that neither *azotic*, *carbonic*, nor *hydrogenous gas* can ſupport reſpiration, it therefore follows, that the *oxigenous* is the only one fit for

* From the experiments of ſeveral eminent perſons on this gas, it would appear, that it exerts a poſitive operation in the lungs, and that it is in itſelf deleterious. The Abbé Fontana found extreme difficulty in taking three inſpirations of it. Theſe apparent contradictions will reconcile themſelves when we conſider the power which this gas poſſeſſes of diſſolving charcoal, ſulphur, phoſphorus, and ſeveral of the metals.—One poſitive experiment, like thoſe mentioned in the text, ought to have more weight than an hundred negative ones.

this purpofe; for the exiftence of any other in our atmofphere is not afcertained.

This *gas*, like every other, is a compound fubftance. It is formed of a radicle or bafe, called *oxigene*, held in folution by *caloric (heat, fire, igneous fluid, matter of heat)* to the point of faturation, which conftitutes its principle of elafticity.

From the numerous experiments which have been made, it appears that *oxigenous gas* is capable of fupporting refpiration only a certain time; and that air is refpirable in proportion to the quantity of this gas contained in it. Count Morozzo placed ten fparrows fucceffively under a glafs filled with oxigenous gas; the firft died in five hours and twenty-three minutes, and the air became confiderably diminifhed in quantity; the fecond died in two hours and ten minutes, the third in lefs time, and fo on; the duration of their exiftence diminifhing in proportion to the diminution and vitiation of the air. Others, that were placed in atmofpherical air, died much fooner than thofe in oxigenous gas; the collective duration of the exiftence of three fparrows placed fucceffively in the latter, being three times greater than in the former; correfponding with the proportion of oxigenous gas prefent. Chaptal fays, that air in which five fparrows had died, yielded only feventeen hundreths of vital air.—As we have fhewn, that none of the gafeous parts of the atmofphere are capable of fupporting refpiration

except

except the oxigenous, it muſt be from a diminution of this that breathing becomes difficult in crouded aſſemblies without free ventilation.

The above cited experiments ſhew that air is diminiſhed by animal reſpiration. The loſs in one hour, by the breathing of a man, is 360* cubic inches, which will contain, according to the experiments of LAVOISIER, 130 grains of ſolid oxigene. Now, it is impoſſible for this gas to be diminiſhed in bulk, unleſs by cold or by preſſure, without decompoſition; and in order that ſuch decompoſition may take place, it is neceſſary that ſome ſubſtance ſhould come in contact with it, for which its oxigene has a ſtronger attraction than it has for its caloric: Such a ſubſtance exiſts in the lungs of animals, and ſhall be pointed out in its proper place.

As oxigenous gas is decompounded in the lungs, reſpiration may be conſidered properly a ſpecies of oxigenation. Accordingly, it is found that the ſame changes take place in the air during calcination, combuſtion, and fermentation, as in reſpiration. Theſe proceſſes require ſimilar circumſtances to favour them, and produce ſeveral phænomena common to each. 1. Oxigenous gas is required. 2. Caloric is diſengaged. 3. Oxigene becomes fixed.

4. The

* "M. DE LA METHERIE has proved that 360 cubic inches of vital air are abſorbed in an hour. My experiments have not ſhewn ſo great a loſs." CHAPTAL'S CHEMISTRY.

The eſtimate of the loſs of air in an hour by HALES, is the ſame as that of LA MATHERIE. See his Staticks.

4. The augmentation of the weight of the products is equal to the weight of oxigenous gas employed.

If refpiration is a fpecies of oxigenation or combuftion, why does not the difengaged caloric manifeft itfelf in the form of light and flame? The reafon is readily affigned.—The procefs of oxigenation varies according to a variety of circumftances. In order that it may go on in a rapid manner, it is neceffary that the fubftance to which the oxigene is attached fhould have a ftrong attraction for it, and that it fhould be in a temperature moft favourable to fuch an attraction. It is likewife neceffary that it fhould be concentrated, and not diffufed through a mafs of incombuftible matter. There is but one of thofe favourable circumftances exifting in the lungs of animals: the fubftance by which oxigene is attracted there, has indeed a ftrong affinity for it, as fhall be fhewn; but it is diffufed through a fluid unfufceptible of combuftion. The temperature of animal bodies is probably not the moft favourable to a rapid procefs. The difengaged caloric will, under thefe circumftances, confequently, be invifible, a fufficient quantity not being evolved in any given fpace of time to manifeft itfelf by the properties of flame and light. Moreover, as foon as the caloric is let loofe in the lungs, it is communicated to the formation of the vapour and carbonic acid gas which are continually exhaling from the lungs.*

As

* Whether the vapour exhaling from the lungs of animals is formed there, by the union of hydrogene paffing from the blood with the oxigene

As the diminution of *oxigenous gas* by animal reſpiration is conſtant and ſucceſſive, we muſt look for ſome ſubſtance in the lungs to which its baſe becomes attached. We know of no other matter there which has an attraction for *oxigene* ſufficient to diſengage it from its *caloric*, except the *blood*. In reſpiration, therefore, the ſolid matter of oxigenous gas muſt unite with this fluid. I am of opinion, that the oxigene of all the gas which is decompounded in the lungs paſſes into the blood.

The

from the air, or whether it be a fluid exhaled from veſſels already formed, is doubtful. The latter conjecture I think the moſt probable; for CHAPTAL ſays, that when hydrogenous gas is taken into the lungs of animals repeatedly, it does not alter either its quantity or quality: If hydrogene is conſtantly exhaling from the blood, ought not the volume of gas to have been augmented?—I intend hereafter to determine this point, by placing animals in hydrogenous gas; if this aqueous fluid is then exhaled, it muſt be ſecreted from the blood. From a cat which I ſaw Profeſſor KEMP place in a tolerably good vacuum, this halitus was exhaled, and manifeſted itſelf by condenſing upon the ſides of the receiver.—This fluid appears to poſſeſs the properties of water, and muſt therefore be formed in the exhalant arteries; for I do not know of a drop of water, QUA AQUA, in the animal body. It is tranſparent, almoſt taſteleſs, and evaporates by heat without coagulation or leaving any reſiduum.

That carbonic acid gas exiſts in greater quantity in the air expired from the lungs of animals than it did previous to inſpiration, is proved by its rendering lime-water turbid, reddening the tincture of turnſole, and by carbonating alkalies when cauſed to paſs through them. See GOODWYN's inaug. diſſert. PRIESTLY on air. CHAPTAL's Chem.—I am inclined to believe that the compound radicle of this gas is formed in the blood, and not in the veſicles of the lungs; for, "according to the experiments of the Count DE MILLY, and the obſervations of FOUQUET," carbonic gas is conſtantly paſſing off from the ſkin as well as the lungs. If "air be placed in contact with blood, it acquires the property of precipitating lime-water."

Whether the aqueous matter and carbonic acid are formed in the lungs or not, they require a large quantity of caloric to convert them into the gaſeous ſtate; and muſt, no doubt, take up all the caloric which is extricated from the oxigenous gas in the lungs.

The decompoſition of ſuch a quantity of *oxigenous gas* as takes place in reſpiration, muſt produce ſome correſponding change in the blood; for experiments ſhew that this ſubſtance is a very general and powerful agent in nature. It was long ſince obſerved by LOWER, that the blood which flowed from the pulmonary veins was more florid than that which flowed from the artery. The ſame fact has been ſince taken notice of by BOERHAAVE, HALLER, CIGNA, HEWSON, GOODWYN, &c. &c. The blood, then, acquires a more florid appearance during its paſſage through the lungs.

The cauſe of this florid appearance has been made the ſubject of the prize queſtions of many learned ſocieties. It was a long time attributed to *nitre* in the air, from the property which this ſubſtance has of communicating a red colour to blood out of the body. BOERHAAVE attributes it to texture; HALLER to a mixture of *oily* and *ferrugenous matter*; HALES to *ſulphur*; HEWSON to the efficacy of the *ſpleen* and *lymphatic glands!* The fact is, there have been as many conjectures reſpecting the cauſe of it, as there have authors written on the ſubject.—It was left for the immortal PRIESTLY to prove that the blood is indebted to what he calls *dephlogiſticated air* for its red colour.*

He

* The Doctor does not appear to have had an idea of the decompoſition of this gas in reſpiration; he ſuppoſes it moſt fit for this purpoſe of any of the airs, becauſe "it contains the leaſt phlogiſton;" and therefore, according to his idea, it is the beſt ſolvent or menſtruum for that principle. Hence, ſays he, reſpiration is a "phlogiſtic proceſs, the uſe of the lungs

He expofed a quantity of venal blood to common air, and found that by agitation it immediately became red; but this was more eminently the cafe when oxigenous gas was ufed, and in a fhorter time.* Blood rendered florid in this manner, and blood taken from an animal in this ftate, were expofed to *hydrogenous*, *azotic* and *carbonic gafes*; the florid colour immediately difappeared, and the blood became black; but upon expofure to *oxigenous gas*, it foon refumed its former appearance. Blood becomes red in proportion to the quantity of oxigenous gas contained in the air to which it is expofed.

HEWSON

being to difcharge that phlogifton which had been taken into the fyftem with the aliment." But as all the phænomena which the Stahlians afcribe to the difengagement of phlogifton, are produced by combinations with oxigene, the experiments of Dr. P. are equally applicable to our purpofe, as if they were made upon the principles of the French Chemiftry.

* Here it will be pertinent to remark, that as blood is rendered fluid fooner, and in a greater degree out of the body, by expofure to oxigenous gas than to atmofpherical air, it is certainly preferable, in cafes of fufpended animation, to inflate the lungs with it. GOODWYN found by ufing this inftead of common air that he could reftore animals fooner. This gas I conceive, might be exhibited with great advantage in fevers of the typhoid kind, in dropfies, chlorofis, and other difeafes of debility. It is eafily procured, and is not a very dear remedy, as 1200 cubic inches can be obtained from one pound of nitre; and one pint from an ounce of minium. It is a grand defideratum to find a mode for obtaining it from water. Mint, lavender, and many other fragrant plants emit it in copious quantities, and might be placed in a fick room with great advantage; they would be pleafing to the eye, grateful to the fmell, afford a ftimulus to the heart, and would abforb the unrefpirable part of the air. CHAPTAL relates a cafe or two of its beneficial influence in pthifis pulmon. The breathing of this air "diffufes an agreeable warmth in the breaft, infpires cheerfulnefs, renders the patient happy:—In defperate cafes, it muft certainly be a precious remedy which can fpread flowers on the borders of the tomb, and prepare us in the gentleft manner for the laft dreadful effort of nature.

HEWSON ſays, that he injected air into a vein between two ligatures, and found that the contained blood aſſumed a more florid appearance. BECCARIA expoſed blood in vacuo; it immediately became black. PRIESTLY ſays, that he repeated the experiment with the ſame reſult.

The blood does not come in actual contact with the air in the lungs. That oxigenous gas can act through membranes apparently more denſe and impermeable to air than the veſicles of the lungs, is evident from the following experiment of Doctor PRIESTLY. A quantity of black blood was incloſed in a bladder, and expoſed to the air; when it was examined, it exhibited the ſame florid appearance as if it had been in actual contact with that fluid, the bladder appearing to be no obſtruction to the proceſs of *floridation.*

It is a curious and intereſting fact, that oxigenous gas can act on blood although it be covered with a ſtratum of ſerum of the depth of two inches and an half: whereas the ſlighteſt covering of oil, ſaliva, or water, effectually prevents its action.

As florid blood becomes black in vacuo, or when expoſed to any of the unreſpirable gaſes; as this colour is reſtored by expoſing it to oxigenous gas, which at the ſame time becomes diminiſhed; as blood is changed from black to red by oxigene out of the body, whether it be imparted to it from acids, neutral ſalts, oxigenous gas, or gaſes containing a portion

portion of this; we may ſafely conclude, that this principle is the immediate cauſe of the ſame change which the blood undergoes in the lungs.

Priestly found by experiment, that if ſucceſſive quantities of florid blood were placed in contact with a quantity of hydrogenous or azotic gaſes, they became in a degree reſpirable, and that nitrous air became leſſened in bulk, at the ſame time loſing its power of diminiſhing oxigenous gas.—Theſe phænomena, according to his theory, he aſcribes to the abſorption of *phlogiſton*, by the blood, from the air: but any perſon verſed in the doctrines of the new chemistry will perceive, that they are owing to an emiſſion of oxigenous gas, the baſe of which exiſts in the blood.—This view of the ſubject affords an eaſy and ſatisfactory anſwer to the unphiloſophical queſtion, whether air exiſts in the blood in an elaſtic form? That the baſe of air exiſts in the blood, and that it will eaſily aſſume the gaſeous ſtate, is evinced from the experiments juſt mentioned; but if a vein be taken out of an animal with a ligature paſſed round each end, and it be placed under an exhauſted receiver, it will not ſwell; or if an artery or vein is punctured under water, not even the ſmalleſt bubble of air aſcends. If air was to be injected into the veins of an animal, it would deſtroy its life; for we muſt be convinced from the analogy of the blood veſſels to hydraulic tubes, that a ſmall quantity of air in any of their ſuperior flexures would effectually obſtruct the circulation of the blood.

The blood of *fiſhes*, of the *fœtus in utero*, and of the *chick in ovo*, is red. Are not theſe objections to the theory which ſuppoſes that *oxigene* is the *floridifying principle* of blood?

That *aquatic animals* require air for the continuance of their exiſtence as well as the *terrene*, is rendered ſufficiently evident from the well known fact, that fiſh in the winter will ruſh in crowds to holes which form or are formed in the ice—an artifice frequently uſed for taking thoſe animals. This poſition is further corroborated by the following experiments. If a few fiſhes are placed in a veſſel of water, and the air be effectually excluded, they will ſoon die. The ſame takes place in vacuo.

Theſe creatures ſeem to ſuffer the ſame inconvenience from being crowded together in a ſmall quantity of water, as men or other land animals do, when in confined places—the water probably not being ſufficiently permeable to air to afford them neceſſary ſupplies.

The experiments of PRIESTLY throw great light on this part of our ſubject, and furniſh ſufficient data to prove, that *oxigene* is neceſſary to the floridification of the blood of fiſhes.—He incloſed a number of theſe animals in different veſſels, containing water, with atmoſpheres of nitrous, hydrogenous, azotic and carbonic gaſes; under which circumſtances they died in a ſhort time—in the carbonic gas they expired convulſed. He likewiſe placed two ſmall fiſhes

fiſhes in a pail of water: after they had been in twenty-four hours, he found that the water had loſt its property of purifying air. In repeating the experiment with water which contained air of great purity, he found, after the fiſh had died in it, that the air which it contained had not only become diminiſhed in quantity, but alſo that its quality was worſe than that in which a candle goes out.

From theſe experiments it appears, that the gaſes which are noxious to land animals, are unfit for the reſpiration of fiſhes. From the diminution of the quantity of pure air in the water in which theſe animals had been, it is evident that they decompound oxigenous gas, and that, like terrene animals, they want conſtant ſupplies of freſh air.

With reſpect to the young of animals *in utero*, it is now rendered ſufficiently evident, that they are ſupplied with arterial (oxigenated) blood by the umbilical vein.—Whether the veſſels of the placenta have a power of taking up chiefly that part of the blood in which oxigene reſides, or whether the arteries of the uterus tranſmit to the veins of the placenta chiefly that part, is doubtful. Probably this will not appear neceſſary when we advert to the well aſcertained fact, that the blood of women during pregnancy, and probably of other animals, manifeſts a highly florid colour.—So wiſely has Nature adapted means to ends, and upon ſuch beautiful principles has ſhe conſtituted the animal œconomy, that the irritability

irritability and tone communicated to the ſyſtem by a diſtention of the uterus, ſhould act as a phyſical cauſe in increaſing the power of oxigenating blood, in order that the fœtus may be ſupplied without injuring the mother.

> "The gen'ral ORDER ſince the whole began,
> "Is kept in NATURE, and is kept in MAN."

That *oxigenation* is neceſſary to the blood of the *chick in ovo*, is manifeſted from the fact, that if the communication between the membranous lining of an egg-ſhell and the external air be cut off, it is incapable of being hatched. If I had time ſufficient for the purpoſe before me, I would try if it was poſſible to hatch chickens in any of the unreſpirable airs, and whether oxigenous gas would facilitate that proceſs. That their ſhells are permeable to oxigenous gas, may be inferred from the putrefaction of eggs. When animal ſubſtances putrify, carbonic acid gas is exhaled; and from analogy I conclude this to be the caſe with them. Oxigene is eſſential to the formation of carbonic acid, and if it could not penetrate their ſhells, it is probable that they would never putrify. It is a notorious fact, that if they are coated with, or immerſed in any ſubſtance which will exclude the air from them, they may be preſerved from putrefaction, even during the warmeſt ſeaſons, for a long time. The membrane which lines the internal ſurface of the ſhells of eggs, is found to be turgid with blood in advanced incubation; probably it performs the office of oxigenation for the chick whoſe lungs are inactive.

Here

Here arifes a curious and important queftion—*important*, becaufe, if it could be fatisfactorily anfwered, we fhould be in poffeffion of a never-failing mean of increafing the energy of the fanguiferous fyftem:—*To which of the component parts of the blood does the oxigene become united, and what is its nature and properties?*

The inferences drawn from the experiments of PRIESTLY and others, fhew that oxigene is the *floridifying* principle of the blood; but what is the nature of that principle which is capable of being *floridified*, remains to be determined by experiment. 1. It muft refide particularly in the colouring part of the blood. 2. It muft be common to the blood of all red blooded animals. 3. It muft have a great affinity for oxigene at a moderate temperature.

Iron, as a principle always prefent in red blood, feems to promife a happy explanation of this phænomenon. The arguments which prefent in favour of this being the floridifiable principle, are, 1. It is always prefent in the blood of animals. 2. It is found in the greateft quantity in the colouring* part. 3. It has an univerfal agency in nature, " in colouring clays and ftones from the darkeft brown to the moft beautiful red." 4. The union of this fubftance with oxigene

* The blood is here fuppofed diftinguifhable into three feparate parts, ferum, coagulable lymph, or fibrous portion, and colouring part.—According to the moft accurate analyfis of the blood, iron refides exclufively in the colouring part.

oxigene produces a colour ſimilar to that of the blood. 5. It is a ſubſtance friendly to animal bodies, increaſing the denſity, floridity, and circulation of the blood. 6. It is one of the moſt combuſtible of the metals, and eaſily reduced to an oxide (calx) by oxigene.—Does not the quantity of iron in blood accord with the degree of its floridity?

Theſe arguments do not appear ſufficiently cogent to afford full ſatisfaction. The attraction of iron for oxigene at the temperature of animals, is not ſufficiently great to account for that inſtantaneous change which the blood undergoes in the lungs, or when expoſed to oxigenous gas out of the body. The proportion of iron found in blood, does not appear ſufficient to account for its florid appearance; but when we conſider how much colour depends upon texture, this objection will not militate ſo ſtrongly. A quantity of red oxide of iron, equal in weight to that which is obtained from a given weight of blood, will not diffuſe that beautiful red appearance through ſo large a maſs of water as the colouring matter from an equal quantity of blood. Red oxide* of iron does not remain in ſolution, in water, like the colouring part of the blood. Upon the principles of this theory, iron ſhould be a more certain

* The oxides of iron differ in colour according to their degrees of oxigenation; ſome containing not more than from twenty to twenty-five parts of oxigene to the hundred; while others have this principle in the proportion of thirty-two or thirty-four hundreths; in which laſt ſtate they form a beautiful red, like carmine. FOURCROY, vol. i. p. 413.

certain remedy, always increaſing the quantity of colouring matter, and conſequently the floridity.*

Upon the whole, the preſence of iron in red blood is not ſufficient to account for all the changes which take place in the lungs of animals. It is, therefore, neceſſary to call in the aid of ſome other of the component parts of the blood, by which we ſhall be able, either ſingly or conjunctly with iron, to account for them in a ſatisfactory manner.

Phoſphorus, as another never-failing principle in the compoſition of red blood, will afford much aſſiſtance in the ſolution of this difficulty. The circumſtances, which *a priori* appear in favour of this ſubſtance, are, 1. That it is always found in the blood of animals. 2. That its attraction for oxigene is very ſtrong, and that at a *low temperature*. 3. Human

* Chalybeates probably do not produce any great effect till they are taken into the circulating maſs. They then form a baſe, or increaſe the power of ſome other ſubſtance exiſting in the blood for the attachment of oxigene in the lungs. The blood, being more highly oxigenated, will ſtimulate the extreme arteries of the ſyſtem to greater action; and a greater quantity of caloric will be evolved from the combined ſtate in a given time. Heat being one of the greateſt ſtimuli of animated nature, will further excite arterial action even to the moſt minute ramifications. Accordingly we find, that iron is "conſidered one of the moſt powerful tonics. It increaſes the force of the heart, acts upon the ſecreting powers, improves digeſtion, and invigorates the whole ſyſtem." (MOORE's Mat. Med.) That iron does enter into the blood by the lacteals, is proved by its being preſent in a preternatural quantity in the urine of perſons who have been under the uſe of it, and by their blood being of a more florid colour, containing more than a natural quantity of this ſubſtance. (MENGHINI quoted by FOURCROY and CHAPTAL.)—This explanation, of the operation of iron, accounts for its good effects in cachexies, and ſhews how and why it is ſo effectual in reſtoring the floridity of the countenance and freſh colour of the whole body.—May not iron be given in conjunction with phoſphorus, or the phoſphoric acid with advantage?

man calculi become of a florid red, as does alſo the blood, if oxigene be communicated to them by the nitrous acid. 4. Animal ſubſtances receive the red dye better than any other. Probably theſe two phænomena are not only produced through the intervention of phoſphorus, but alſo of iron, as both are preſent.*

A great quantity of phoſphoric acid is formed in the animal body. It enters largely into the compoſition of bone. It exiſts in a naked ſtate in the gaſtric juice. It is found in the blood. In fact, it enters as an ingredient in almoſt all the parts of animal bodies. Large quantities are daily evacuated from the ſyſtem through the urinary organs, and by the ſkin.

As oxigene is the great *acidifying* principle through nature, phoſphorus can only be brought into the acid ſtate through the intervention of this principle; and as it is impoſſible to conceive of any other way in which oxigene can have acceſs to the blood but by the lungs, it is evident that this ſubſtance muſt acquire its oxigene directly from the air during the paſſage of the blood through that viſcus, or indirectly from ſome ſubſtance which had previouſly undergone the

* Whether theſe ſubſtances are formed in the bodies of animals or not, is not to the preſent purpoſe to inquire; it is ſufficient to have aſcertained that they are never-failing ingredients in red blood. If they are formed in animal and vegetable bodies, they are not ſimple ſubſtances, as they are at preſent eſteemed. The chemiſtry of nature is not ſufficiently attended to. The marine acid radicle, alkali, and probably calcarious earth can be formed in the bodies of animals.

the procefs of oxigenation there.—There is no fubftance in the blood from which phofphorus could receive oxigene in this indirect manner except iron. As the attraction of phofphorus for oxigene at the temperature of animal bodies is greater than that of iron, and as they are equally expofed to the influence of this principle in the lungs, the former muft neceffarily undergo the greateft change.

Thefe confiderations induce me to believe that the florid colour of blood is owing to iron and phofphorus, brought into a ftate of union by oxigene. I am inclined to believe that thefe fubftances are united in the blood, becaufe oxigene is the bond of union between *acids* and *metals*, and becaufe the chemiftry of art can unite them through the intervention of carbone (pure coal.) Every circumftance favourable to their union exifts in the blood, together with the more fublime operations of the chemiftry of nature.

The idea then of the procefs, to which I have been conducted by this courfe of induction, is fimply this. During the paffage of the blood through the minute branches of the pulmonary artery oxigene becomes united to phofphorus and forms the phofphoric* acid. The iron is reduced to the ftate of red oxide, partly by the oxigene which it receives in the lungs,

 and

* Nature appears ftudious to accomplifh this object, by expofing the greateft poffible quantity of furface to the oxigenous gas; the area of the air veficles of the lungs being at leaft equal to the furface of the whole body.

and partly by a communication from the acid. When theſe ſubſtances have undergone a certain degree of oxigenation, they become united by a further addition of oxigene; probably at the ſame time ſome other part of the blood may be combined with them, which, when exiſting in a perfect ſtate of union, conſtitute the colouring of the blood. During this union, which not only takes place in the blood while in the lungs, but alſo in other parts of the arterial ſyſtem, carbone is diſengaged; and when the blood is undergoing a change from arterial to venal, it unites with oxigene, and is exhaled from the lungs and ſurface* of the body in the form of carbonic acid. From this view of the ſubject I maintain that ſome of the immediate principles of the blood become the baſe of its colouring part.—Are the laws of the chemical attractions modified by the living principle in this function, or is it, like digeſtion, a pure chemical proceſs?

This theory, which appears to me to be ſupported by a number of facts and ſtrong analogies, is ſufficient to explain all the phænomena connected with reſpiration. The affinity of phoſphorus for oxigene, accounts for the rapid decompoſition of oxigenous gas in the lungs; the union of phoſphorus and iron, for the colour of the blood. It ſhews how blood is changed from venal to arterial, and from arterial to venal. It explains why the blood becomes more red when expoſed to oxigenous gas, although cover-

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* See Note page 12.

ed with a ſtratum of ſerum of the thickneſs of two inches and an half; and why this change cannot take place when it has even the ſlighteſt covering of ſaliva, oil, or water. It ſhews why azotic and hydrogenous gaſes are unſuſceptible of decompoſition in the lungs. And it may ſerve, in ſome meaſure, to throw light on the deleterious operation of carbonic acid in the lungs. The different temperatures of animals, and the different degrees of floridity in their blood, are likewiſe explicable in a degree by this theory. It not only affords a ſatisfactory explanation of the formation of phoſphoric acid in the blood, but alſo explains the ſpontaneous combuſtion of animal bodies, and may, in ſome meaſure, elucidate the gout and ſtone.

Oxigene, deprived of that principle which maintained it in the gaſeous ſtate, and having aſſumed the ſolid form, carries almoſt all its caloric with it. The ſtate in which oxigene exiſts in the air, is that of elaſtic fluidity. It is capable in this condition of having its bulk increaſed like all other ſubſtances in nature, by the addition of caloric. But, when deprived of that portion of caloric which overbalanced the attractive power between its particles, and maintained it in the aeriform ſtate, it aſſumes the ſolid form: in this condition it exiſts in the oxides of metals, concrete acids, &c. On account of its ſtrong tendency to combination it has never been obtained a in ſeparate ſtate, or there is no doubt, but that, like other bodies, it might be brought into the intermediate ſtate of elaſtic fluidity

and

and ſolidity. This may yet be effected by the conjoined action of cold and preſſure. In water and many of the acids, oxigene approaches nearly to this condition; in the former, its proportion is as eighty-five to fifteen of hydrogene.

Lavoisier, when on the ſubject of aſcertaining the quantity of caloric diſengaged during different ſpecies of combuſtion, makes it an important deſideratum in chemiſtry, to find a method for determining the quantity of caloric which oxigene takes with it when it aſſumes the ſolid form. He ſuppoſes, that the oxigene entering into the compoſition of the oxigenated nitric and muriatic acids, takes caloric with it; hence (ſays he) "the violent and dangerous deflagrations which the neutral ſalts, in which theſe acids enter as components, produce with charcoal and many metallic ſubſtances."

The violent exploſion of the *aurum* and *argentum fulminans*, can only be explained upon this principle. Amoniac (volatile alkali) is requiſite to the formation of both, which is itſelf proved to be compoſed of the baſes of hydrogenous and azotic gaſes (hydrogene and azote.) From the analogy of theſe elementary ſubſtances with oxigene, it is preſumeable that they likewiſe take caloric with them when they aſſume the ſolid form. The caloric thus exiſting in the ſolid form in the ammoniac, and alſo in the oxigene of the oxide of the metal, being rapidly diſengaged by the formation of new combinations, is ſufficient to account for all the appearances which theſe

ſubſtances

ſubſtances preſent. Analogous to the fulminating gold and ſilver are gun-powder and the common pulvis fulminans, which explode equally well in vacuo as in open air.—During the exploſion of fulminating gold and ſilver, which will take place in copper tubes, water and azotic gas are produced: the products, after the exploſion of the pulvus fulminans, and gun-powder, are entirely gaſeous.—How can the production of theſe various fluid ſubſtances from ſolids be explained, unleſs it is allowed that caloric, under certain circumſtances, can take the ſolid form; and that the ſame caloric, in conſequence of an alteration taking place in the ſubſtance by which it is held in chemical union, ſhall aſſume another ſtate, and be the cauſe of liquidity and elaſtic fluidity?

Caloric is, no doubt, in a degree condenſed in the natural ſtate of the air; for if thin glaſs bubbles, filled with air, be placed under the receiver of an air-pump, they will burſt; bladders, partly filled with air, under ſimilar circumſtances, immediately ſwell—the latter fact takes place with bladders partly filled with air when taken to the tops of high mountains. Mr. Boyle found air to expand in vacuo one hundred and fifty times; but this falls vaſtly ſhort of the bulk which it is capable of occupying.

It is impoſſible to limit the bounds of the condenſation of air. Boyle made it thirteen times more denſe than it was before he applied the preſſure.

Halley

HALLEY ſays that he has ſeen it compreſſed into one-ſixtieth of its natural ſpace. HALES condenſed it thirty-eight times. It has been lately made to occupy one hundred and twenty-eighth part of its former bulk.

It is evident, that in the condenſation of air, caloric is not ſqueezed out, for it inſtantaneouſly returns to its former condition when the condenſing power is removed, as may be ſeen in the familiar inſtance of the air-gun. It would not only return to its former volume, but would actually paſs infinitely beyond it, was it not for the mechanical preſſure of the contiguous atmoſpherical column. If in the compreſſion of air caloric was forced from between its ſolid particles, it would be in a free or diſengaged ſtate, and conſequently would manifeſt itſelf by heat.

In the expanſion or condenſation of air there is neither an addition nor diminution of caloric, there cannot be of the ſolid matter, caloric can then be made to occupy a greater or leſſer ſpace than it naturally does in air; its particles cannot be in contact even in the moſt condenſed ſtate of air. If caloric is matter, and if it be ſubject to the laws of the chemical attractions, and can exiſt in bodies not only as water does in a ſponge, but alſo in combination; why may it not become part of their ſolid ſubſtance?

From what has been advanced above, it appears that oxigenous gas is decompounded in the lungs. That its ſolid matter, oxigene, becomes the floridifying

ing principle of the blood, and that iron and phosphorus are the substances capable of being floridified. It was then rendered probable from the nature of fluid and solid, and from several phænomena explicable upon no other principles, that the bases of gases when assuming the solid form carry caloric with them.

I now think it probable, that the caloric thus united with the oxigene* in the blood, is evolved in the extreme arteries, and is the greatest source of heat to animal bodies.

In maintaining an opinion that heat is not communicated to animals by the blood from the lungs, but that it is evolved in every point of the body which contains arteries, I know that I shall act in opposition to the sentiments of great names—*Amicus* PLATO *sed amica veritas magis.*

Although we do not know in what manner arteries evolve combined caloric into the free or sensible state, yet that its evolution is connected with the action of the arterial system is an obvious truth. But whether this depends upon the action of the arteries, or upon that cause by which arterial action is directly produced, will be difficult to determine.

* "One hundred parts of phosphorus require one hundred and fifty-four parts of oxigene for saturation." It has been already observed, that the proportion of oxigene in the red oxide of iron is as thirty-four to one hundred. If one hundred and thirty grains of oxigene are combined with the blood in one hour, three thousand one hundred and twenty must be fixed in the course of one day, which appears to me to carry combined caloric sufficient to be adequate to the effect of the heat of the human body.

mine. We certainly know, that arteries poſſeſs the power of decompounding the blood, and of recompounding it again, as in the various ſecretory organs of the ſyſtem. Analogous to this, is that change which the blood undergoes from arterial to venal, as it paſſes through the extreme arteries into their anaſtamoſing veins. As the affinities of bodies for caloric, and capacity for containing it, are changed when they undergo any chemical alteration, it is eaſy to conceive that blood, when it undergoes the change juſt mentioned, ſhall throw out a quantity of its combined caloric, which will manifeſt itſelf in the ſenſible form. During this change of blood from red to black, diſengaged oxigene may unite to its carbone, and form the carbonic acid which is exhaled in ſuch quantities from the lungs and ſkin.—The blood being deprived of its oxigene, by its union with carbone, by a quantity of phoſphoric acid going to the formation of bones and other purpoſes, and by a portion of this acid conſtantly paſſing off by the kidneys and ſkin; the ſyſtem at the ſame time continually generating phoſphorus; it is again prepared to attract oxigene in the lungs, and thus is kept up the perpetual round of changes in the blood from venal to arterial, and from arterial to venal during the exiſtence of animals.

The idea of animal heat, which is deduced from the theory of reſpiration already given, is ſimply this. By the decompoſition of oxigenous gas in the lungs, a quantity of oxigene is communicated to the blood.

blood. The oxigene thus combined carries a large portion of its caloric with it; which is gradually evolving by the oxigene forming new combinations during the circulation, and which becomes more completely evolved in the extreme arteries by that power which changes blood from arterial to venal. and in the various secretory organs

This idea of animal heat reſts on the following obſervations, and its eaſy application to the explanation of phænomena. The heat of animals is in proportion to the extent, perfection, and vigour of their lungs: thus birds are warmer than terrene animals; theſe latter are warmer than the amphibious, and theſe ſtill more ſo than fiſhes, whoſe temperature is ſcarcely above that of the element in which they live. Animals appear to deſtroy oxigenous gas in proportion to their temperatures. The blood of animals is found to correſpond with their lungs; that of land animals containing a greater quantity of craſſamentum, and being more florid than thoſe which live both on land and in water, and theſe latter again more ſo than fiſhes, whoſe blood is pale, aqueous, and in ſmall quantity. The ſtate of the blood does not only differ in the different claſſes and ſpecies of animals, but alſo in individuals of the ſame ſpecies: " in infants, delicate women, and weakly men, it is paler, and leſs diſpoſed to coagulate, than in robuſt healthy perſons. The blood is thin and pale coloured in cachexies, but in diſeaſes of an oppoſite diatheſis it is highly florid, and contains a large proportion of craſſamentum, correſponding with the weakneſs or

 ſtrength

ſtrength of the pulſe. Any cauſe increaſing the energy and action of the arteries, increaſes heat. Every part of the body containing arteries, is ſuſceptible of inflammation,* or an increaſed generation of heat, even the *vaſa vaſorum* of the lymphatics; and that in proportion to vaſcularity and ſenſibility. Inflammations are generally circumſcribed, which would not be the caſe if heat was communicated through the body by a mere diffuſion from the lungs. Every part of the body is capable, in a certain degree, of ſupplying itſelf with heat, according to its exigencies. Children have been born with marks of the ſmall-pox, the ſuppuratory proceſs of which diſeaſe implies inflammation.

If

* Inflammation is confined to the extreme arteries. The phænomena of this diſeaſe all concur in ſhowing that there is an increaſed impetus of the blood in the veſſels of the part affected; and, as at the ſame time the action of the heart is not evidently increaſed, this is ſufficient reaſon to conclude that the increaſe of heat in the part is owing to an increaſed action of the veſſels independent of the heart. An increaſe of action in any ſet of veſſels produces preternatural heat. Active inflammation may therefore be defined AN AUGMENTATION OF THAT POWER BY WHICH CALORIC IS EVOLVED FROM THE COMBINED TO THE FREE STATE. A topical accumulation of excitability or ſtimulability will render the veſſels of that particular part more ſuſceptible of the action of the oxigenated blood, by which means their action will be increaſed (not their energy), and conſequently a greater quantity of blood will circulate through the part in a given time than in health, and by this means a greater quantity of heat be evolved. Inflammation may thus continue by the part generating its own ſtimulus, till nature relieves the veſſels by reſolution or ſuppuration: but if the excitement of the part be raiſed too high by the ſtimulant operation of heat, that principle upon which the ſtimulus acts will be worn out; the part being thus deprived of that principle, which, when preſent, modified the agency of ſeptic powers, it will conſequently be left to the deſtructive action of external agents, decompoſition will enſue, and the components of the ſkin, muſcular fibres, &c. form binary combinations, which conſtitutes ſphacelus.—Upon this principle of a part generating its own heat, the continuance of inflammation can be accounted for, without ſuppoſing a ſpaſm to exiſt in the extreme ends of arteries to ſupport their action, or without recurring to a VIS MEDICATRIX for its formation.

If the heat of animal bodies was all evolved in their lungs, the following propoſitions would be found to be juſt. 1. The parts of the animal body would be cool according to their diſtance from this ſuppoſed centre; for it is an eſtabliſhed law in Nature, that heat ſhall decreaſe as it recedes from the ſource from which it originated. 2. No part would be ſuſceptible of an increaſed degree of heat. 3. No part could reſiſt the topical application of cold. 4. The *fœtus in utero* would generate no heat, and conſequently would be unſuſceptible of inflammation. The accurate obſerver of the phænomena of animal bodies will perceive that the reverſe of theſe is the fact.

If the animal body had not the power of preſerving itſelf nearly at one uniform temperature, it would be impoſſible for it to exiſt. Heat is an agent which regulates chemical attractions: if the body was raiſed much above, or ſunk much below its natural ſtandard, the chemical operations which it performs would be varied, new combinations formed, and death enſue. It was, therefore, neceſſary that the temperature of animal bodies ſhould be nearly equable, whether they were expoſed to the cold of Siberia, or to the burning heat of the torid zone.

To ſupport this regularity, Nature has made abundant proviſion. In the frozen regions of the earth, and during cold ſeaſons of the year, atmoſpheric air contains a greater quantity of oxigenous gas

gas under a given volume, than it does in warm climates and ſeaſons; and, according to the idea, p. 30, a greater quantity of caloric is contained in condenſed than in rarefied air, and moſt certainly more oxigene. Under theſe circumſtances a greater quantity of oxigenous gas will be decompounded in the lungs, in a given time, than in warm climates and ſeaſons, and conſequently a greater quantity of oxigene fixed in the blood. If this fluid is ſtimulant to the ſanguiferous ſyſtem in proportion to its degree of oxigenation, the animal ſyſtem will be able to preſerve one uniform temperature, whether it be expoſed to an atmoſphere at the freezing point of mercury or at the boiling point of water.* When the atmoſphere is cold, and conſequently the animal body deprived of a great quantity of heat by its mechanical contact, the air is moſt replete with oxigene and caloric, which are the great cauſes of animal heat. The contrary takes place when animals are ſurrounded by a warm atmoſphere.

According to my arrangement of this ſubject, I have only to mention the effect of reſpiration on the action of the heart. The connection between the ſtate of the breathing and the pulſe has been noted by BOERHAAVE, HALLER, ZIMMERMAN, M'BRIDE, GREGORY, and every other writer on phyſiology and pathology.

* It is a well known fact, that the human body is not colder in the northern regions, where mercury has been known to freeze; and the experiments of BLAGDEN and FORDYCE ſhew that its temperature is not much increaſed when expoſed to air where FARENHEIT'S Thermometer ſtood above two hundred and forty degrees.

pathology. This natural connection between theſe two vital functions has been brought to account for the ſucceſs of HIPPROCATES in curing diſeaſes; who, it is ſaid, almoſt neglected the pulſe, but attended particularly to the ſtate of the breathing.

GOODWYN ſuppoſes that the heart is indebted only to the chemical change which the blood undergoes in the lungs for the ſupport of its inceſſant action. He therefore denies that the dilatation of the thorax is the final cauſe of reſpiration; and aſſerts that the circulation of the blood through the lungs, even in the moſt perfect ſtate of expiration, is ſufficient to ſupport the life and health of animals. The death of animals by drowning and ſtrangulation, he ſuppoſes to be owing to venal blood paſſing from the right to the left ventricle of the heart unchanged.

HALES and HALLER ſuppoſe that the dilatation of the lungs is neceſſary to the free tranſmiſſion of blood through them. The former of theſe authors goes ſo far as to ſuppoſe that this is the only uſe of reſpiration.

It appears to me that the truth (as uſual) lies between theſe two extremes: the blood not only appearing to ſtimulate the heart in conſequence of being oxigenated in the lungs, but alſo by mechanically diſtending it.

If the concluſion of GOODWYN was founded in Nature, would there be that intimate connection between

tween the frequency and force of the heart's action and the frequency and fullneſs of reſpiration? Would the ſuſpenſion of reſpiration produce that turgeſcence and redneſs of the face which it is invariably found to do? From HALES's account of his experiments on dogs, it appears that the circulation of the blood was ſupported in a kind of mechanical manner, by forcibly diſtending the lungs with air, which muſt have been much vitiated by its having been frequently taken into the lungs of the animal. CULLEN obſerves, that "the tone of the arterial ſyſtem depends upon its tenſion." I know of no reaſon why this will not apply to the heart in ſome meaſure. The right or anterior ventricle of the heart acts without the ſtimulus of arterial or oxigenated blood. This GOODWYN ſays is becauſe the venal blood is its proper ſtimulus. Does it not act by the ſtimulus of oxigenated blood in the fœtus ſtate?—According to GOODWYN's idea, a different organization is implied in the ventricles of the heart, to render each ſuſceptible of its peculiar ſtimulus, which is not proved.

Upon the whole, I am induced to conclude, that the uninterrupted action of the heart is owing to the evolution of caloric from the oxigene of the blood as it paſſes from the lungs to the heart, to the oxigene which changes the blood from venal to arterial, and to the mechanical action of the blood.

Is

Is the tenacity of the hearts of animals, for their vis infita or irritability, increafed in proportion to the diminution of the power of their refpiratory organs in decompounding oxigenous gas?—and do their temperatures decreafe in the fame ratio?

From the doubts, difficulties, and uncertainties which occur in attempting to explain the phænomena of refpiration (and indeed of almoft every other function of the animal œconomy) I am convinced that much more is ftill to be done. There are not yet a fufficient number of facts collected, and experiments made, to conftitute the bafis, or ferve as data for reafoning in a fatisfactory manner; I have no doubt, and I have analogy in my favour, that this will foon be done. A genuine fpirit of inveftigation prevails—Revolutions are taking place in every fpecies of knowledge—Medicine does not remain ftationary; and from the unbounded profpects which chemiftry opens to view, I have no doubt but that a period is commencing which will mark a glorious æra in the hiftory of this fcience.

FINIS.